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WAmerica's Resource for
Real-Time and Forecasted
Air Quality Information

by Richard Wayland and Timothy Dye

Air quality affects everyone. The average person breathes approximately 15,000 liters of air each day.¹ More than 159 million people in the United States live in areas designated as nonattainment for the National Ambient Air Quality Standards (NAAQS) for ozone (O₃) and fine particulate matter (PM_{2.5}).² Emissions sources such as cars, buses and trucks, and power plants; industrial sources; and individual actions all contribute to the creation of polluted air and poor air quality. Timely information about air quality and education regarding the links between air quality, health, and causes of air pollution can lead to a healthier and better educated society.

The ability to provide the public with real-time and forecasted air quality information is critical to protecting public health. Knowing current or forecast air quality levels allows individuals to take actions to reduce their exposure to unhealthy air. For many individuals—particularly, children, outdoor workers, and those who suffer from respiratory problems or cardiac conditions—knowing the quality of the air they breathe affects the quality of their lives and how they plan their daily activities. It can also lead to reduced hospital visits for the treatment of respiratory problems triggered by poor air quality. In a recent study in southern California,³ for example, approximately 7% of parents of children with asthma reported fewer hospital visits on poor air quality days as a result of air quality warnings.

In addition, having real-time and forecasted air quality information available to the public can foster successful voluntary emissions reduction programs. Many U.S. cities use

air quality forecasts to declare air quality action days and offer incentives such as free mass transit to reduce the number of cars being driven on those days.⁴ In addition, businesses may alter their production processes to reduce emissions. The U.S. Environmental Protection Agency's (EPA) AIRNow program is a nationwide, voluntary program that provides real-time air quality data and forecasts to protect public health. The program was developed to provide easy access to current, accurate, and reliable air quality information.

THE AIRNOW PROGRAM

In 1994, the Maryland Department of the Environment began mapping O₃ air quality. Greater efforts followed, coordinated by the Northeast States for Coordinated Air Use Management and EPA Region 1 on the East Coast, and the Sacramento Air Quality Management District in California on the West Coast.⁵ In 1997, through EPA's Environmental Monitoring for Public Access and Community Tracking (EMPACT) program, the AIRNow program was able to take the concepts developed by these early air quality communications innovators a step further to create a national-scale program for reporting real-time air quality information to the public using EPA's color-coded Air Quality Index (AQI). Program coverage has expanded from 14 northeastern states and O₃ data only in 1997 to nationwide and real-time O₃ and particle pollution data (measured by continuous PM_{2.5} monitors, not Federal Reference Method)

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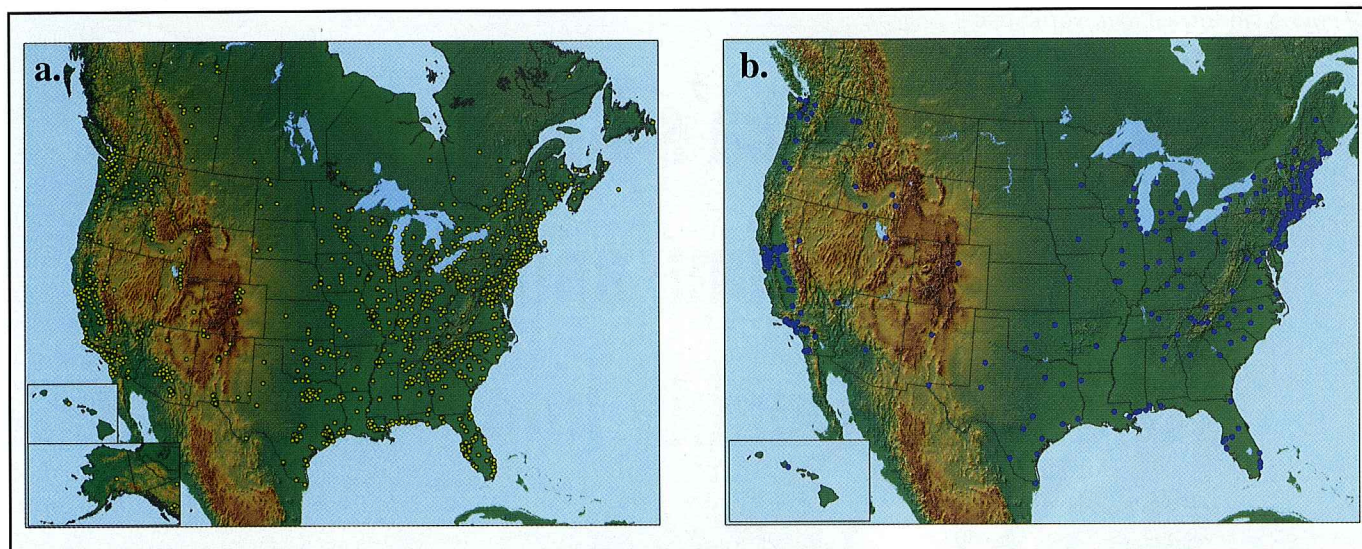


Figure 1. Map showing the locations of (a) 1800 monitors that provide data to the AIRNow program and (b) 320 cities that provide local forecasts to AIRNow.

from more than 1800 monitors in all 50 U.S. states and 6 Canadian provinces and next-day air quality forecasts for more than 320 cities in the United States (see Figure 1). Before AIRNow, a central repository for all real-time data in the United States did not exist.

The AQI, a uniform indicator to report air quality data and forecasts to the public (before 2000, it was called the Pollutant Standards Index), covers criteria pollutants— O_3 , $PM_{2.5}$, PM_{10} , sulfur dioxide (SO_2), carbon monoxide (CO), and nitrogen dioxide (NO_2)—and uses colors, health descriptors, and pollutant-specific health-effects information to convey the quality of the air. When the index is above 100, air quality becomes unhealthy.^{6,7}

AIRNow serves many communities, including the public, the media, forecasters, and research scientists, and has become America's resource for real-time and forecasted air quality information. The program provides real-time and archived animated maps for O_3 and $PM_{2.5}$, official next-day forecasts for U.S. cities, news stories and graphics, coverage of special episodes (e.g., wildfires), and educational materials about health and the actions people can take to reduce their exposure and contribution to air pollution. All this information is available on the AIRNow Web site (www.airnow.gov) as well as for dissemination to media partners through their normal data delivery channels. The Web site features news on air quality events happening in the United States and provides multi-day outlooks

for upcoming air quality conditions. In addition, it has special sections for air quality conditions for most of the national parks, real-time images from Web cameras linking air quality and visibility impacts, a children's Web page and an associated teacher curriculum, smoke Web page, and public outreach materials in English and Spanish.

SYSTEM OVERVIEW

AIRNow comprises a large voluntary community of organizations working together to protect public health. As shown in Figure 2, the core community consists of 120 stakeholders (local, state, federal, tribal, and provincial agencies) that deliver local data and provide local air quality forecasts to

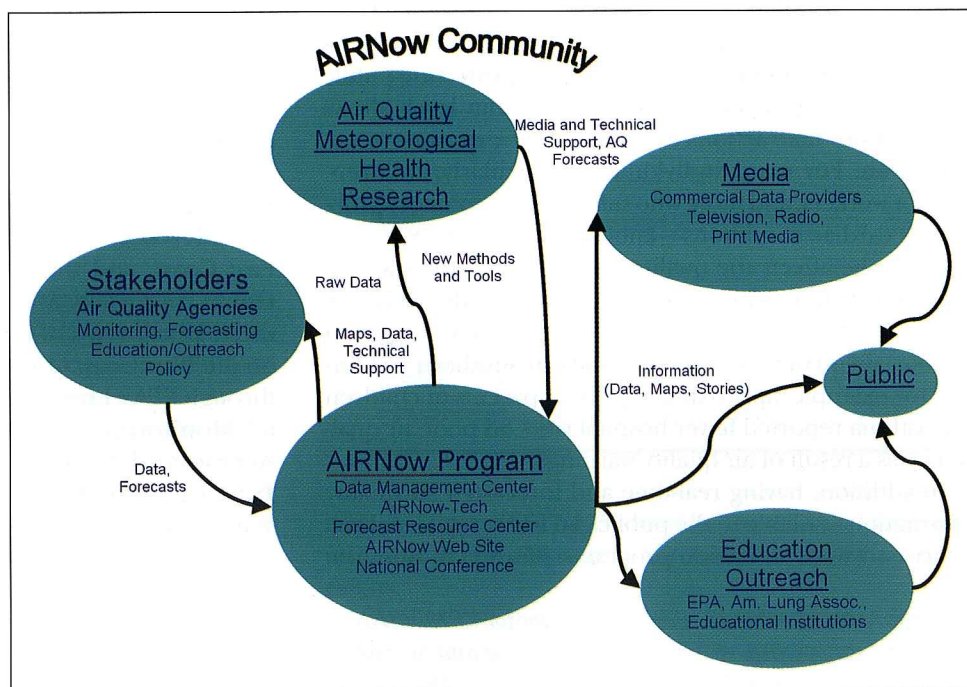


Figure 2. Schematic showing the major organizational groups in the AIRNow community and the flow of data and information.

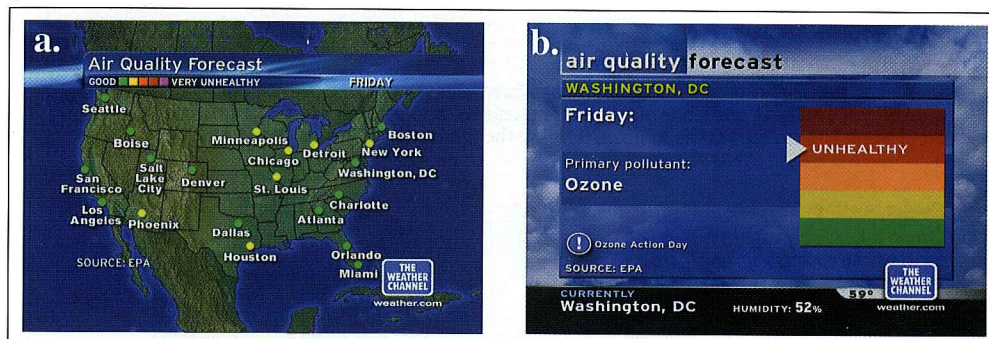


Figure 3. The Weather Channel coverage of air quality forecasts uses (a) a national air quality forecast map that is shown during its morning broadcasts and (b) local metropolitan air quality forecasts that are shown on its "Local on the 8s" segment.

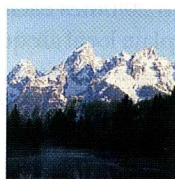
the AIRNow Data Management Center (DMC). The DMC serves as the hub for acquiring, processing, and distributing data and information. Air quality, meteorological, and health researchers are key participants who provide new methods and techniques for improving real-time data collection, new forecasting methods, and new insights and studies into the health impacts of air pollution. AIRNow's information is distributed to media outlets, to outreach/education organizations, and ultimately to the public.

Data flow from the agencies to the public is rapid and highly automated. Each hour, 120 agencies acquire data from their monitoring sites and send the latest air quality data to

products to media outlets and the public in real time.

Air quality forecasts issued by state and local air quality agencies predict maximum AQI levels for the current and next-day periods. Each day, state and local forecasters submit their forecasts to the AIRNow program for more than 320 cities; most forecasts are for O_3 and $PM_{2.5}$, but other pollutants (e.g., PM_{10} , CO, and NO_2) may also be forecasted. The forecasts are consolidated and redistributed to media outlets and the public. The AIRNow program links with media companies, commercial weather service providers, and public communications organizations to pass AIRNow information on to the public. Commercial weather

the AIRNow DMC. By approximately 20 minutes past each hour, the AIRNow DMC has received data from all agencies delivering O_3 , $PM_{2.5}$, PM_{10} , and other air quality data from the 1800 monitoring sites throughout the United States and Canada. Within the AIRNow DMC, software automatically processes the data and performs data quality control, generates forecast maps and other data files, sends status e-mails to stakeholder agencies, and distributes the



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service providers redistribute real-time AQI maps and AQI forecasts to hundreds of television stations, newspapers, and Web sites across the United States. In addition, the program works with national media outlets such as The Weather Channel and *USA Today*.

HOW AIRNOW INFORMATION IS USED

AIRNow data are available to millions of people and organizations each hour. The four primary applications for AIRNow information are protecting public health, assisting agencies with outreach and education, supporting scientific studies, and supporting other operational programs. This section provides examples of how AIRNow data are used in each of these four applications.

Protecting Public Health

Access to real-time data, forecasts, and educational information about air quality allows the public, both individuals and organizations such as schools, to determine when and where air quality will affect their health. Each hour, the AIRNow program distributes information to the public in a variety of ways. As shown in Figure 3, The Weather Channel uses

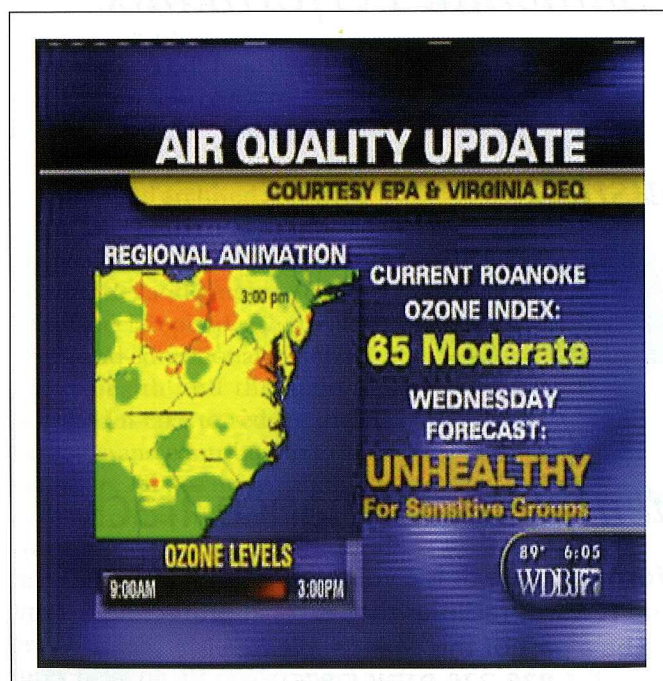
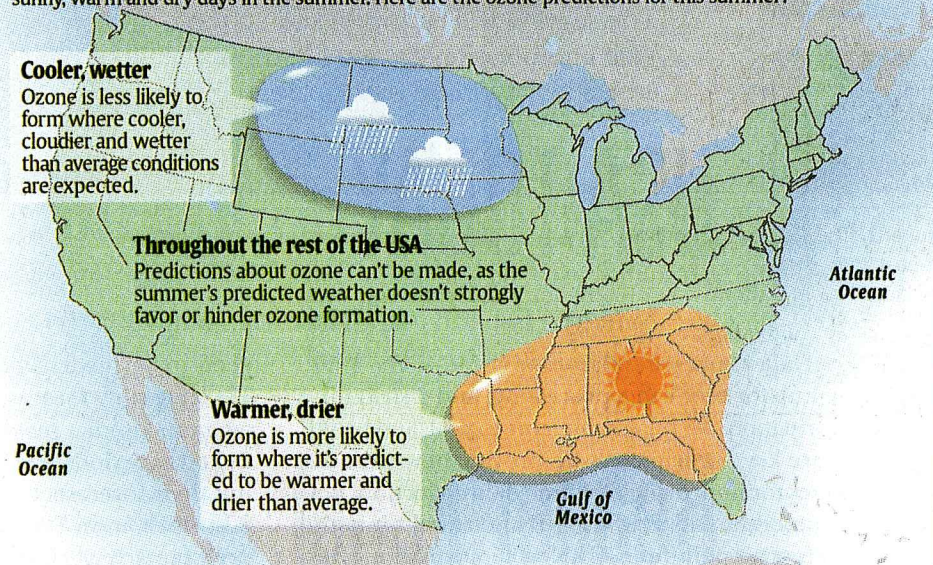


Figure 4. Local TV station (WDBJ) in Roanoke, VA, uses AIRNow maps as part of the evening news weathercast.

Summer ozone outlook

Sunday was the beginning of ozone season, when forecasters look for the pollutants that can cause bad air quality. Ozone is one of the main ingredients in smog, which tends to form on sunny, warm and dry days in the summer. Here are the ozone predictions for this summer:



Source: Environmental Protection Agency

By Alejandro Gonzalez, USA TODAY

Figure 5. Example educational graphic published in *USA Today* produced from an AIRNow news story that discussed the seasonal O_3 outlook for summer 2005.

forecasts from AIRNow to warn the public of unhealthy air quality conditions. During episodes of unhealthy air quality conditions, these forecast maps are shown 20 times each day. Twice an hour, The Weather Channel displays local air quality forecasts from AIRNow on its "Local on the 8s" segment (see Figure 3b). The Weather Channel also redistributes AIRNow data via other methods: local digital cable network, The Weather Channel Radio Network, Weather.com, and Notify! (an e-mail/pager alerting service). Meteorologists at local television stations use AIRNow AQI maps to vividly show current O_3 conditions during their weathercasts, as shown in Figure 4. AIRNow's real-time and forecasted information reaches tens of millions of television viewers.

Local and national newspapers publish air quality forecasts from AIRNow. For example, *USA Today* publishes AQI forecasts on its weather page for 36 major cities reaching more than 2.3 million readers daily. In addition, the AIRNow program regularly provides news stories about air quality to further educate the public and media. Figure 5 illustrates *USA Today's* use of an AIRNow news story on its May 1, 2005, weather page to inform the public about the summer O_3 season.

Current air quality conditions and forecasts are also available on many weather Internet sites. As shown in Figure 6, WeatherUnderground.com, which receives 750,000 visitors per day, provides Internet users with multipollutant, multiday forecasts in an easy-to-read format. Air quality information is closely integrated with weather information on these sites to increase public awareness. Other weather Internet sites using AIRNow information include weather.com, accuweather.com, and weatherbug.com.

Air Pollution Forecast for Woodland			
	Air Quality	AQIndex	Pollutant
Yesterday	Good		OZONE
Yesterday	Good		PM2.5
Current	Good		OZONE
Current	Moderate		PM2.5
Wed	Moderate		OZONE
Thu	Unhealthy for Sensitive Groups		OZONE
Fri	Unhealthy for Sensitive Groups		OZONE
Sat	Unhealthy for Sensitive Groups		OZONE
Sun	Unhealthy for Sensitive Groups		OZONE
Current Air Quality Yesterday's Peak Air Quality Index			

Figure 6. Forecasts for Woodland, CA, displayed on WeatherUnderground.com.

Other notification systems send AIRNow information directly to the public via e-mail, cell phones, and pagers. A number of notification systems have been developed (e.g., AirAlert, www.myairalert.net; EnviroFlash, www.airnow.gov/index.cfm?action=airnow.enviroflash; and SmogAlert, <http://www.cleanaircampaign.com>). These services allow individuals to specify locations and AQI levels for which they would like to be notified. In Sacramento, CA, for example, the local air quality agency runs AirAlert (www.myairalert.net), where users sign up to receive both real-time air quality conditions and forecasts for the greater Sacramento region. This information is sent to subscribers' e-mail (or cell phones) only when conditions warrant. (For more information on AirAlert, see Shearer et al. on page 25).

Assisting Agencies with Outreach and Education

Dozens of state and local air quality agencies use the AIRNow data and maps to communicate local air quality conditions to their constituents. For example, the local air quality agency in Knoxville, TN, shows several types of AIRNow maps on its local Web site to illustrate regional air quality.⁸ Other Web sites use AIRNow data to assist air quality communicators at local agencies. For example, AirShare.Info is a Web portal designed to allow air quality communicators to collaborate and share information. The home page of AirShare.Info shows current and forecasted air quality for rapid assessment of important news stories, current air quality conditions, and forecasts across the United States and Canada and provides local communicators with easy access to national air quality data (see Figure 7).



Figure 7. Home page for AirShare.Info, which provides air quality news and access to AIRNow's real-time data and forecasts.

Scientific Studies and Analysis

Access to nationwide real-time O_3 and $PM_{2.5}$ measurements allows scientists to use AIRNow data for research activities. For example, the Sulfate Transport Eulerian Model (STEM) air quality modeling system assimilates real-time O_3 data from the AIRNow program.^{9,10} As shown in Figure 8, use of real-time AIRNow O_3 data improved the model's predictions. The National Aeronautics and Space Administration (NASA) uses AIRNow surface $PM_{2.5}$ data to provide comparisons with satellite-derived aerosol optical depth measurements (AOD),¹¹ a measure of aerosols in the atmosphere in a vertical column above the earth. Figure 9 shows the correlation between AIRNow $PM_{2.5}$ ground measurements and AOD estimates. These types of plots are produced in real-time for the preceding 60 days to assist air quality forecasters in interpreting how satellite-derived AOD relates to surface $PM_{2.5}$ measurements. Forecasters can then use AOD data as surrogates in areas with few surface monitors.

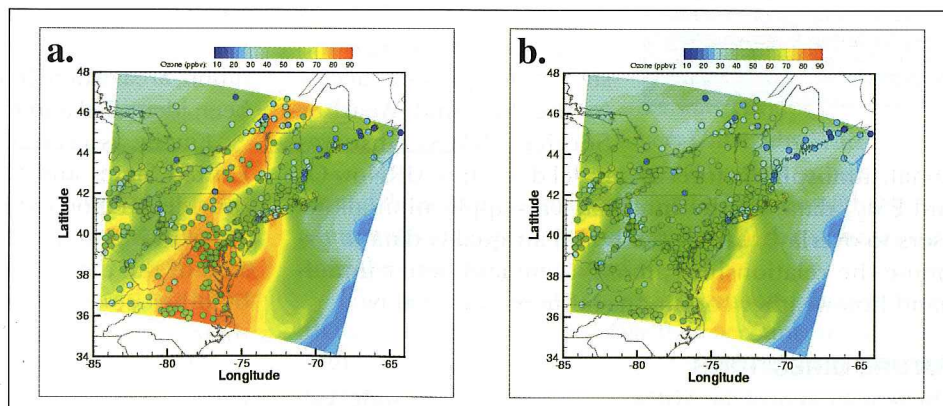


Figure 8. STEM model forecasts for July 20, 2004, in the northeastern United States (a) without and (b) with assimilation of real-time AIRNow O_3 data. Circles show the locations of AIRNow monitors and contour colors show model O_3 predictions.

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Supporting Other Operational Programs

Several other operational programs use AIRNow O₃ and PM_{2.5} data. For example, the National Oceanic and Atmospheric Administration (NOAA) and EPA are developing an O₃ forecast model to provide guidance to state and local air quality forecasters.¹² AIRNow's O₃ data are used by NOAA to evaluate the Eta-Community Multiscale Air Quality (CMAQ) forecast model in real-time. Access to real-time O₃ data allows NOAA to publish verification statistics that forecasters can use to evaluate model performance.

Another example is DataFed.net, a collection of real-time and historical data sources used to facilitate access and analysis of aerosol data to assist air quality management and atmospheric science applications. Operated by Washington University, DataFed ingests AIRNow O₃, PM_{2.5}, and PM₁₀ data and allows users to view other aerosol data sets on the Internet (for more details on the DataFed program, see Husar and Poirot on page 39). Desktop applications also use AIRNow data. For example, NOAA's FX-Net is a weather forecasting workstation that provides access to the National Weather Service (NWS) observa-

tional, atmospheric forecast model data, and AIRNow O₃ and PM_{2.5} data, via the Internet. This application allows users to overlay weather fields and air quality data to examine the relationships among them and better understand how weather conditions influence air quality.

FUTURE DIRECTIONS

The original goal of the AIRNow program was to provide real-time and forecasted air quality data to program partners and the public on a national scale. Having achieved that initial goal, the program is now evaluating new opportunities to use

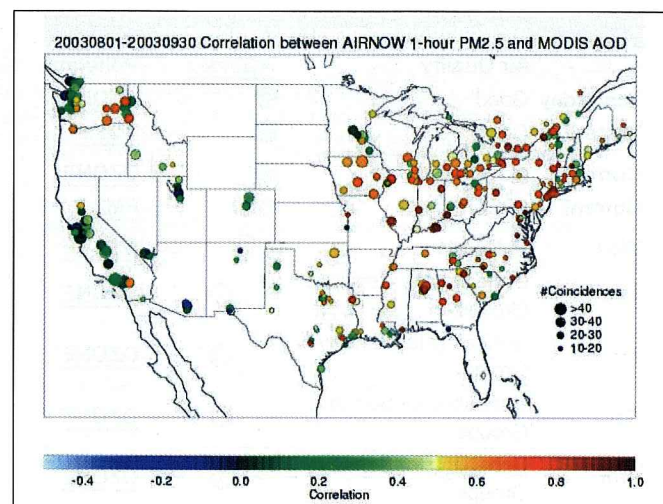


Figure 9. Correlation between AOD estimates and surface PM_{2.5} concentrations for August-September 2003. Correlation is shown for each AIRNow site using color; the size of the circle indicates the number of samples available.

the existing infrastructure to provide even more benefits to stakeholders and the public. There are three primary areas of interest for future growth and expansion.

With the increased capability to monitor and transmit data through wireless communications, the AIRNow program is piloting the delivery and dissemination of real-time air quality data from mobile monitors. This capability would allow temporary monitors to be set up in the event of emergency events, such as wildfires, and transmit data to AIRNow via satellite. The data would then be rapidly available for agencies' use in decision-making as well as for public use in tracking air quality conditions related to such events. To make the system flexible for reporting sensitive data, the AIRNow system has the ability to control the dissemination in collaboration with the reporting agency.

A second area of expansion is the enhancement of AIRNow products. Technology advances in both software and hardware have led to better mapping and data processing tools. Experience in effectively communicating air quality information since the program was developed has led to a better understanding of packaging the information and making it more useful for the public and the media. In addition, areas where information was unclear or missing have been identified and those areas can now be addressed.

Finally, as a result of the success of the program in the United States and Canada, there is a growing desire to provide AIRNow capabilities internationally. AIRNow staff are working to develop an international stand-alone version of the data management center that could be used by other countries to collect, process, and disseminate their air quality data and forecasts in real-time.

The AIRNow program continues to grow. As the demand for access to these types of data increases, AIRNow will position itself to continue to be the single resource for the public, forecasters, and researchers to get timely and useful air quality information. **em**